MODIS Meeting

College Park, MD

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Using MODIS snow cover fraction in the NASA GEOS-5 modeling and assimilation system

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Outline

ROSES Terra/Aqua proposal:

"Enhancing NASA GEOS data products through multi-variate assimilation of land surface observations from Aqua and Terra"

Just getting started…

This presentation:

1. ***Evaluation of GEOS-5 products vs. MODIS SCF***
2. ***Assimilation of MODIS SCF***

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3. ***The SMAP Level 4 Carbon product***

NASA/GMAO GEOS-5 products

MERRA: Recently completed re-analysis

- GEOS-**5.2.0**
- **1979-present, continued** updates w/ **~1 month latency**, global
- Resolution: **Lat=0.5º Lon=0.67º**, 72 vertical levels
- **MERRA-Land**: Enhanced land enhanced product for land surface hydrological applications (Reichle et al., J. Clim., 2011)

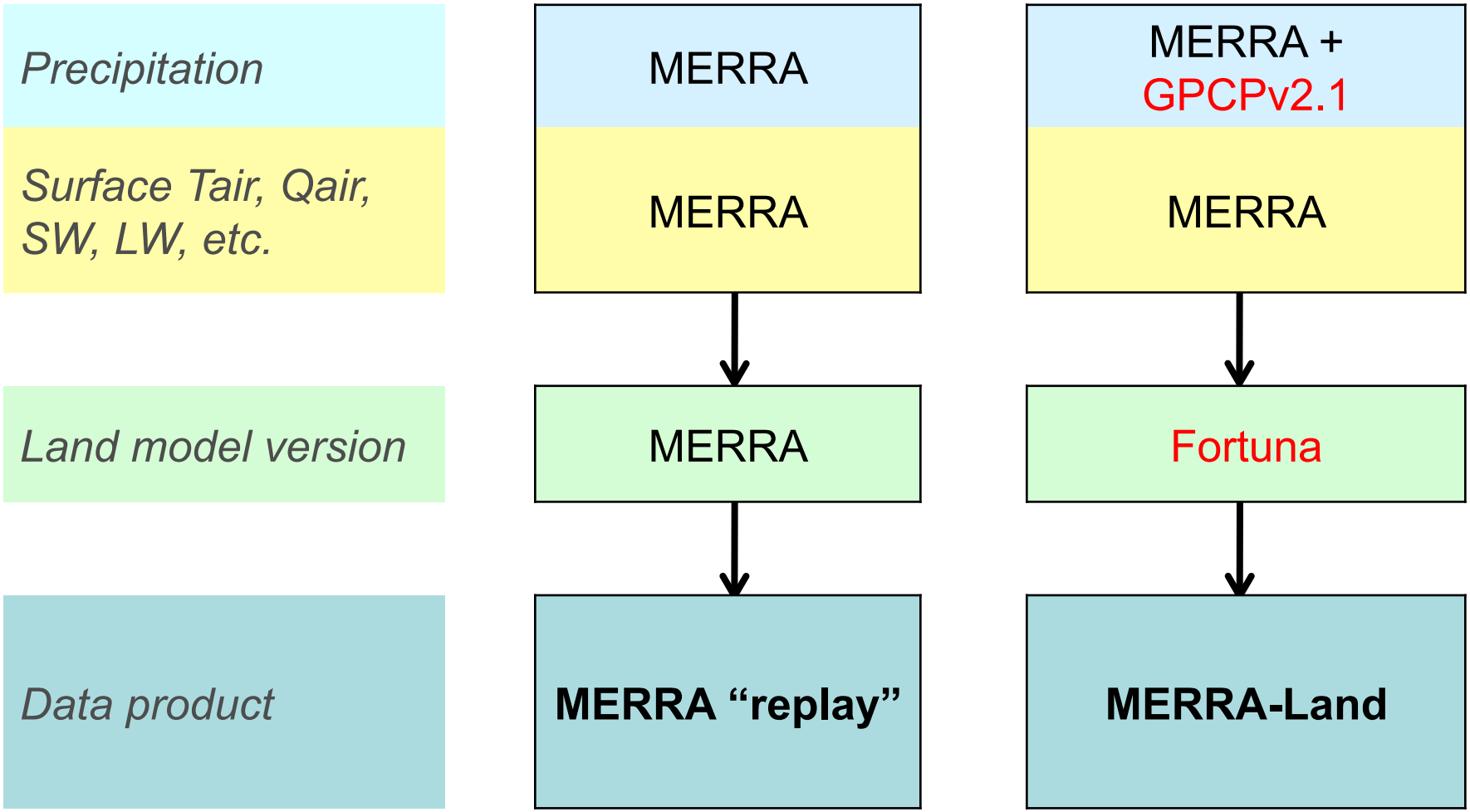
"Forward processing"

- **Near-real time**, global
- Currently using GEOS-5.2.0
- From ~June 2011:

  GEOS-**5.7.1** (incl. GCM revisions a.k.a. "Fortuna")

  Resolution: **Lat=0.25º Lon=0.3125º**, 72 vertical levels

Land-only ("off-line") replay



Catchment land surface model parameter changes

Parameter	Description	Units	MERRA	Fortuna
SATCAP	Capacity of canopy interception reservoir	kg/m^2	1.0*LAI	0.2*LAI
FWETL	Areal fraction of canopy leaves onto which large-scale precipitation falls	[-]	1.0	0.02
FWETC	Same as FWETL but for convective precipitation	[-]	0.2	0.02
WEMIN	Min. SWE in snow-covered area fraction	kg/m^2	13	26
DZ1MAX	Max. depth of uppermost snow layer	m	0.05	0.08

MERRA-Land has improved estimates of soil moisture, runoff, canopy interception, and evapotranspiration (Reichle et al., J. Clim., 2011),

BUT

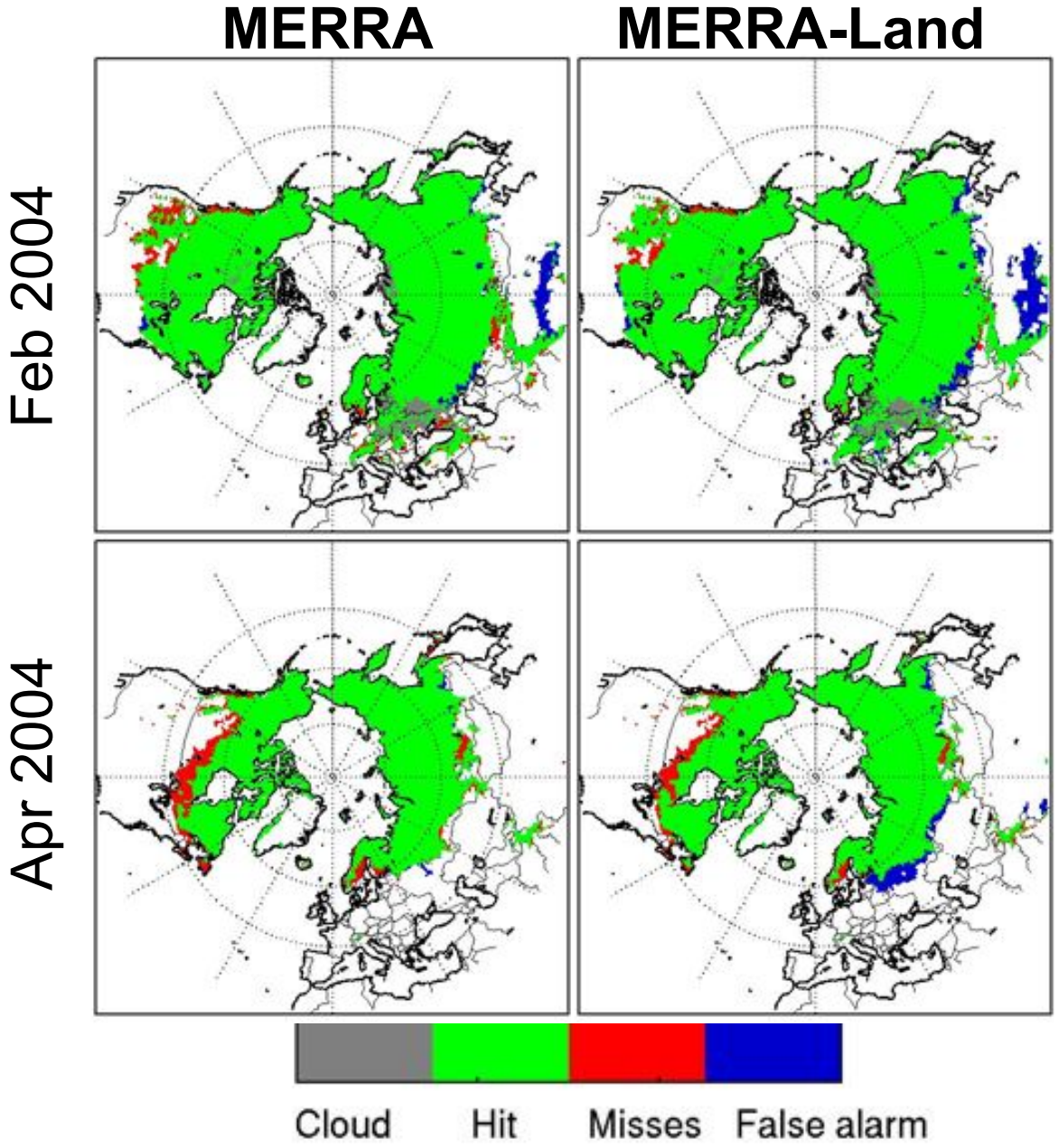
if we look at snow cover fraction and compare to MODIS…

Categorical analysis of snow cover fraction vs. MODIS

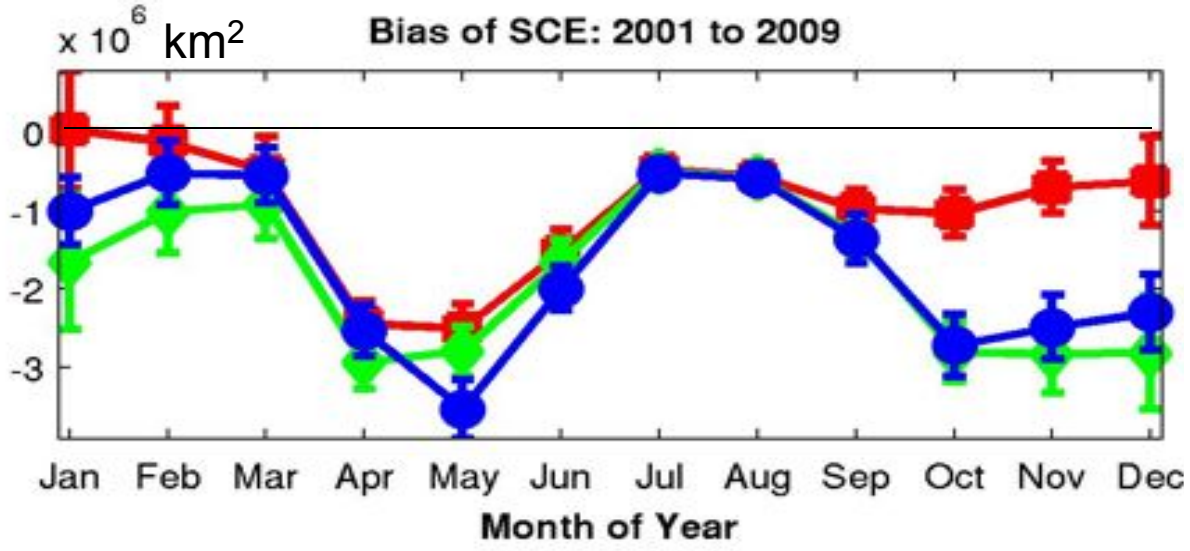
MOD10C2, aggregated to monthly avg. SCF

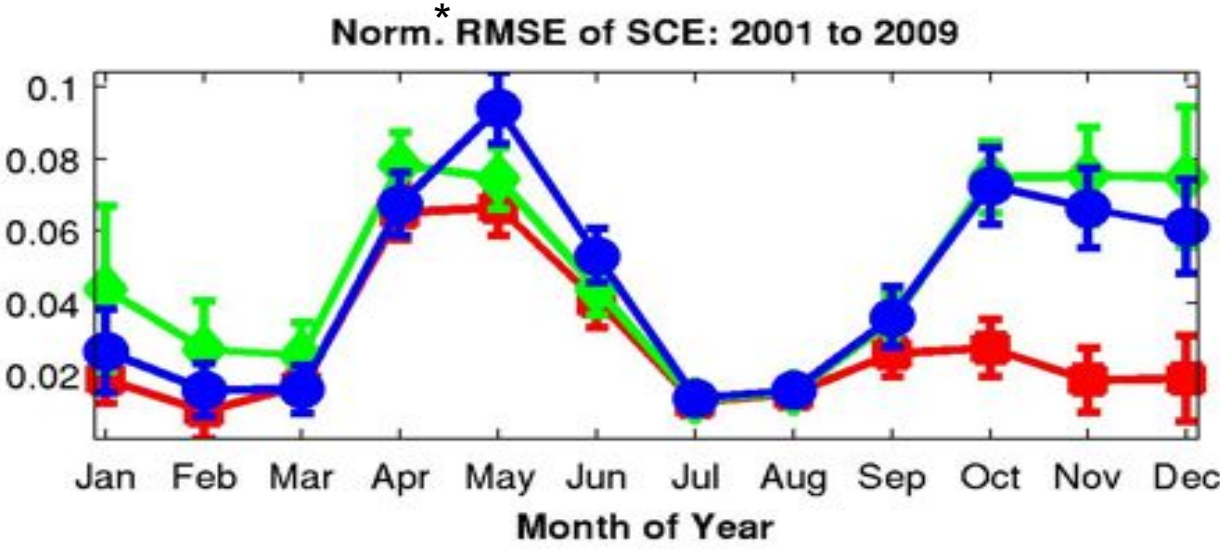
MERRA SCF agrees well with MODIS SCF observations.

False alarm rate increases in MERRA-Land.



Snow cover extent (SCE) v. MODIS





*RMSE normalization vs. max annual SCE.

Change of WEMIN parameter in "Fortuna" unhelpful for estimation of snow cover fraction.

[Not sensitive to GPCP precipitation corrections.]

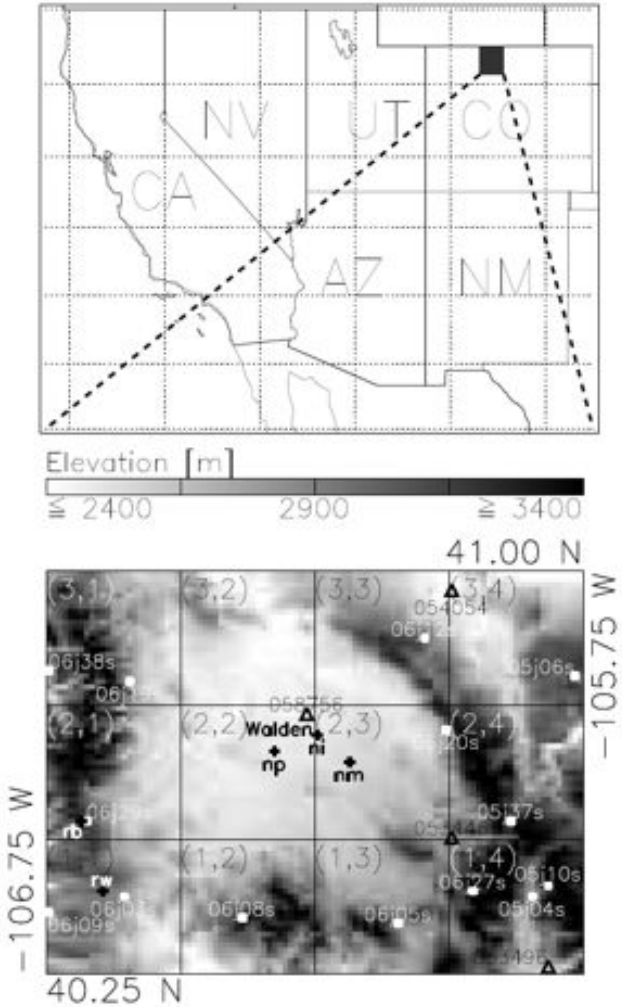
See **poster** by *Toure and Reichle* for details.

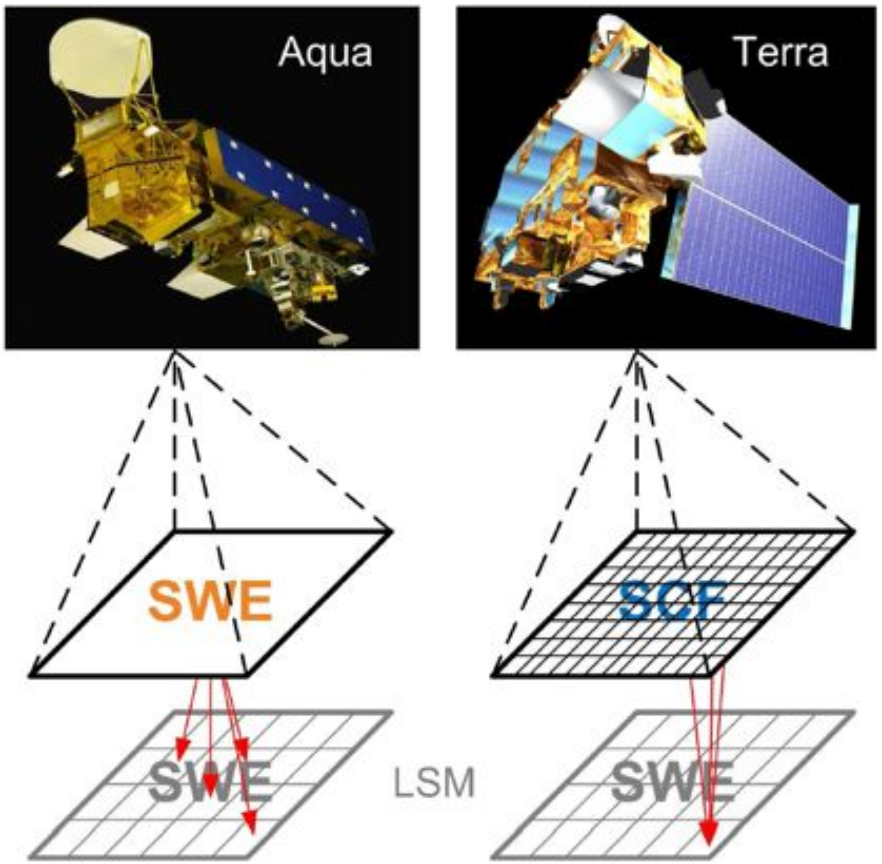
Outline

1. *Evaluation of GEOS-5 products vs. MODIS SCF*
2. ***Assimilation of MODIS SCF***
3. *The SMAP Level 4 Carbon product*

Assimilation of MODIS snow cover fraction (SCF)

Noah land surface model
(1 km resolution)
100 km X 75 km domain
in northern Colorado

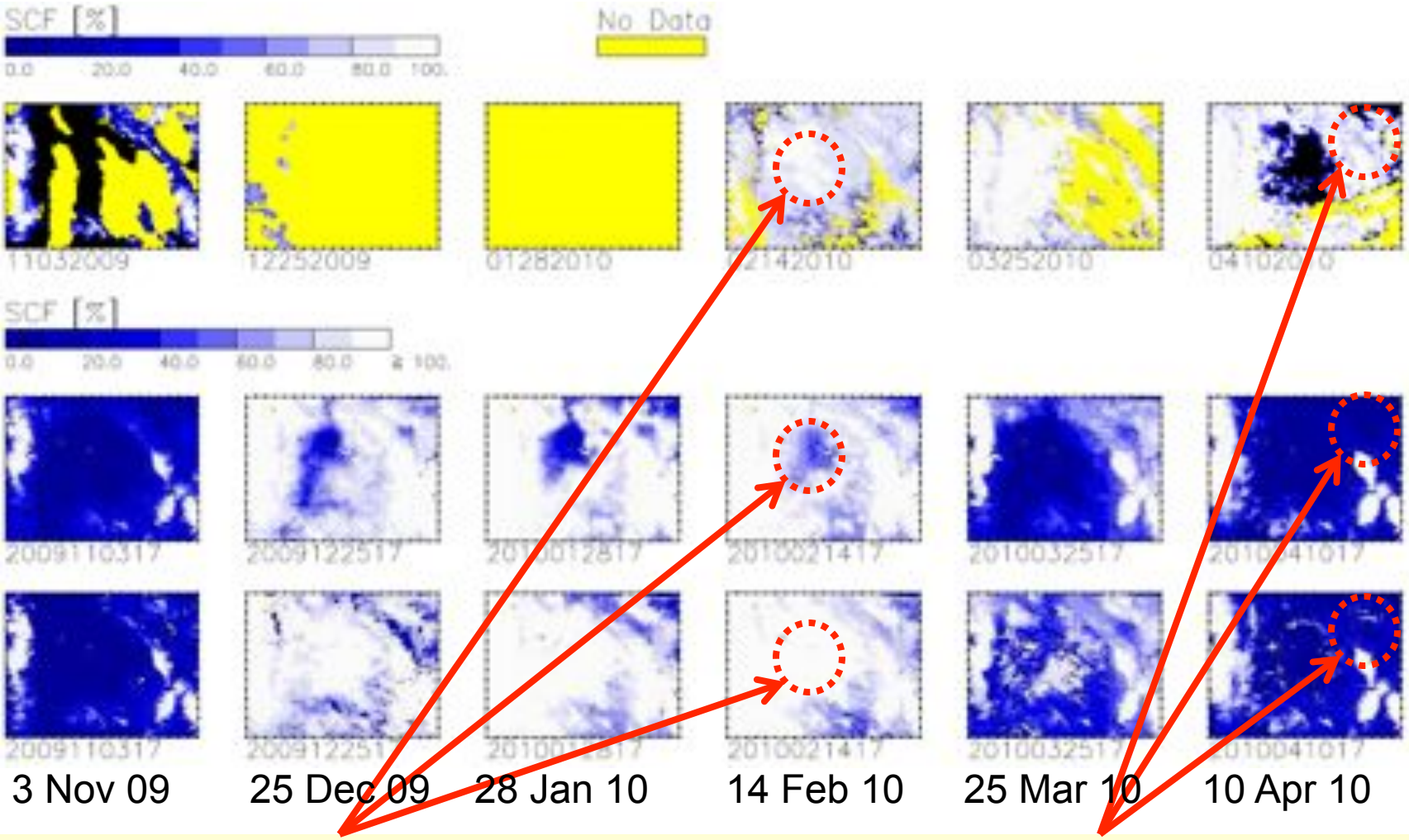




Multi-scale assimilation of MODIS SCF and AMSR-E SWE observations.

Validation against in situ obs from COOP (Δ) and Snotel (▪) sites for 2002-2010.

Assimilation of MODIS snow cover fraction (SCF)



MODIS SCF successfully adds missing snow, … except during melt season.

MODIS SCF also improves timing of onset of snow season (not shown).
See **poster** by *De Lannoy et al.* for more information.

Outline

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3. ***The SMAP Level 4 Carbon product***

SMAP Level 4 soil moisture and carbon products

L4_SM Product:

Lead: Rolf Reichle, NASA/GMAO

Assimilating SMAP data into a land model driven with observation-based forcings yields:

– a root zone moisture product (reflecting SMAP data), and

– a complete and consistent estimate of soil moisture & related fields.

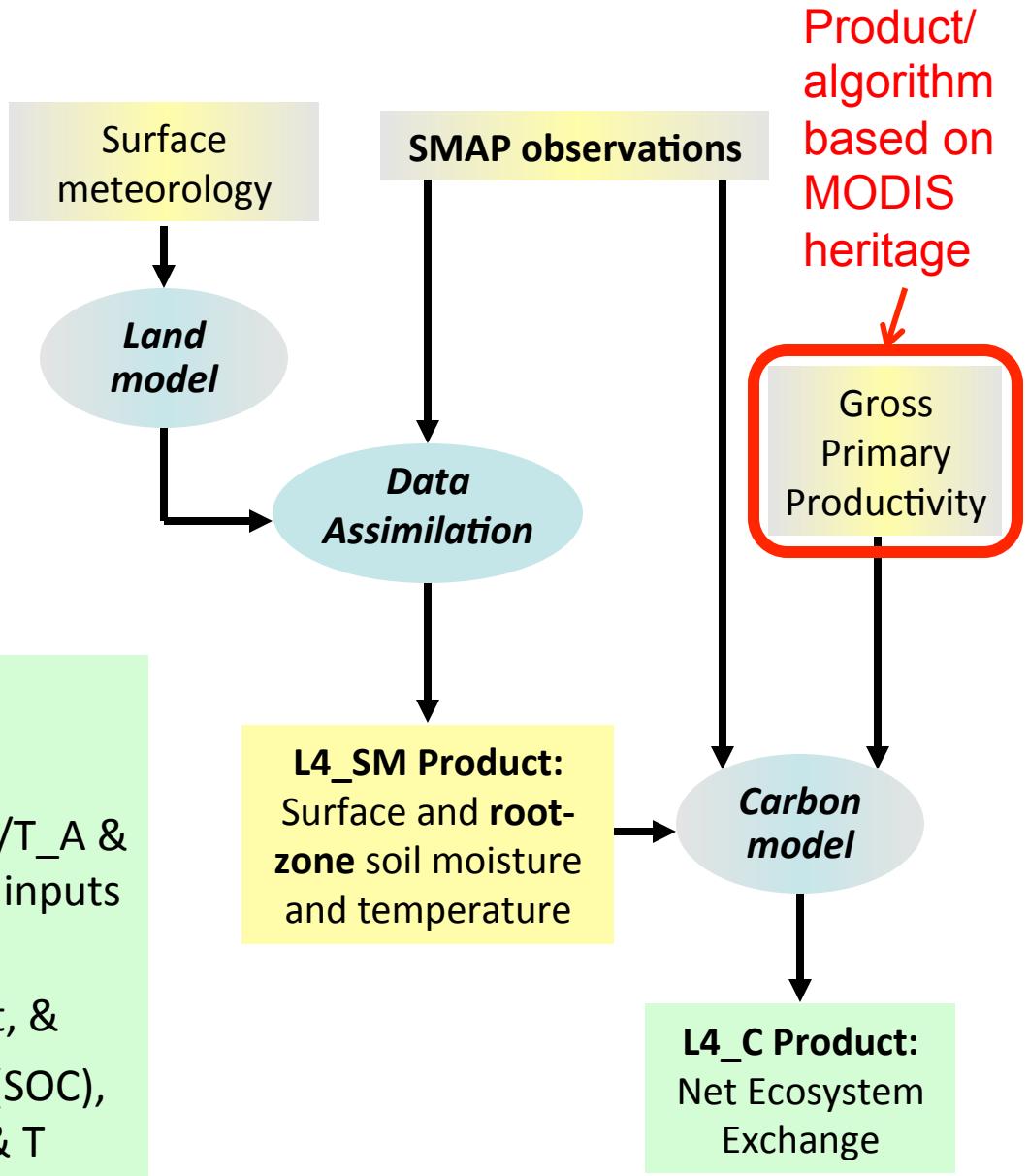
L4_C Product:

Lead: John Kimball, U Montana

Combining L4_SM (SM & T), high-res L3_F/T_A & ancillary Gross Primary Productivity (GPP) inputs within a C-model framework yields:

- a Net Ecosystem Exchange (NEE) product, &

- estimates of surface soil organic carbon (SOC), component C fluxes (R) & underlying SM & T controls.



Summary

Used MODIS snow cover fraction (SCF) to assess GEOS-5.

SCF estimates from (old) MERRA system agree better with MODIS than those from (new) GEOS-5.7.1 system (but SWE estimates are comparable; not shown).

MODIS provides helpful information for model development.

MODIS SCF assimilation:

- can improve model snow estimates, and
- will be included in GEOS-5 land assimilation system.

MODIS GPP heritage contributes to SMAP Level 4 Carbon product.

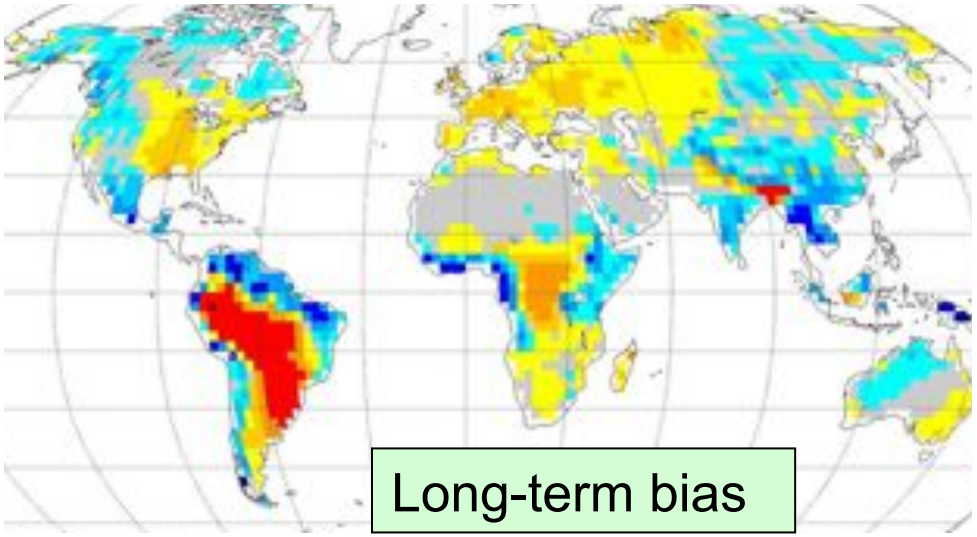
Thanks for listening!

Questions?

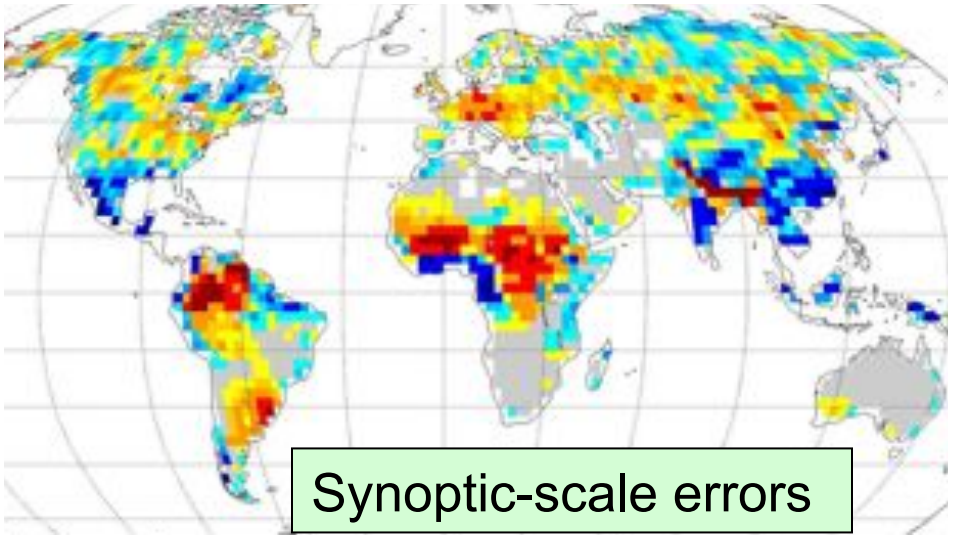
Precipitation

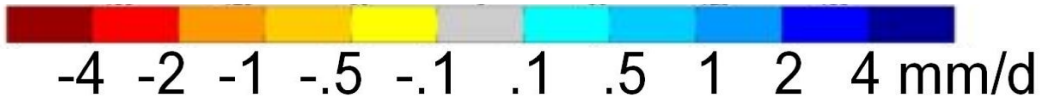
MERRA – GPCPv2.1

1981-2008 [mean=-0.03 mm/d]



Aug 1994 [mean=-0.04 mm/d]

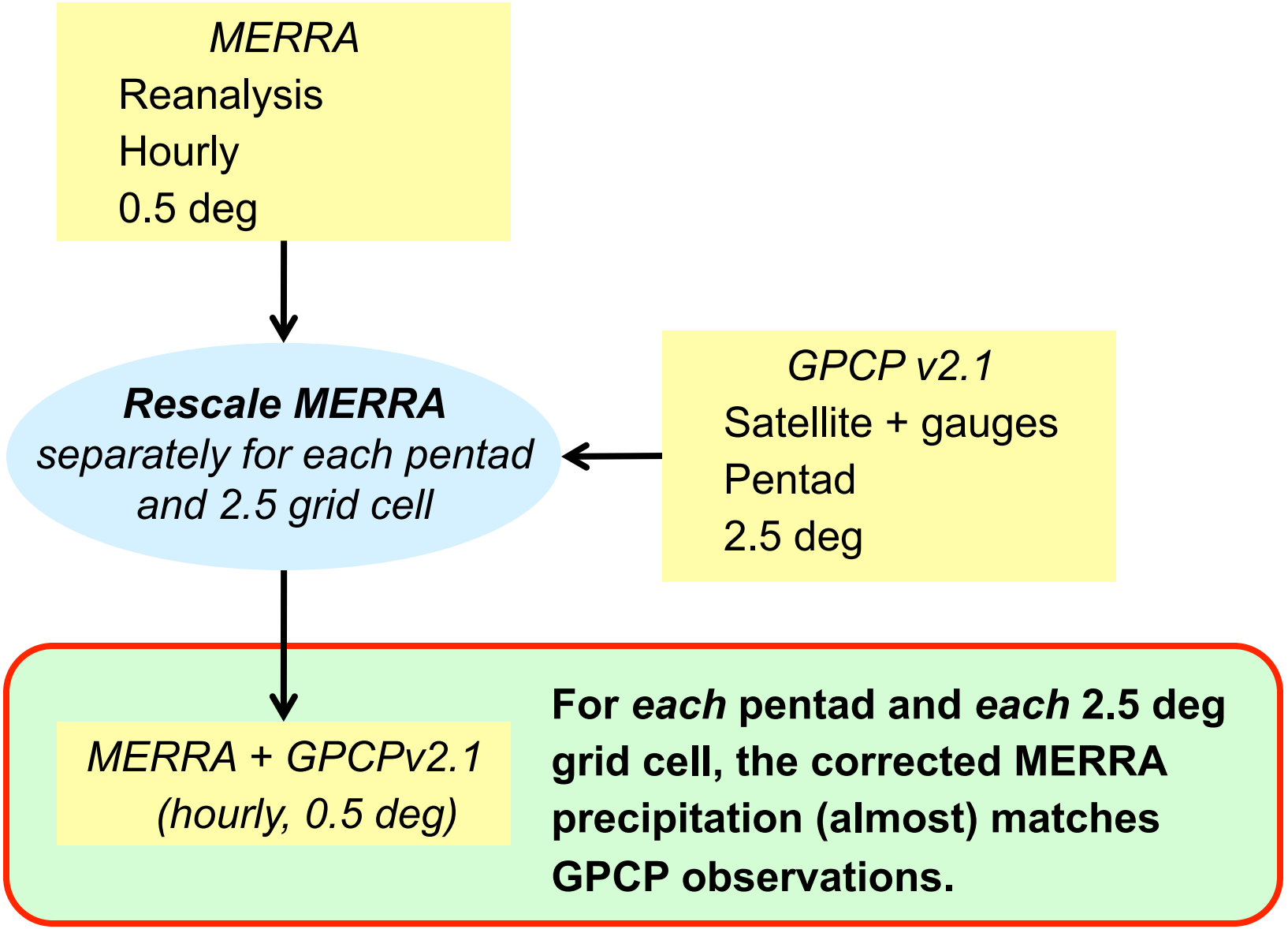




→ Correct MERRA precipitation with global gauge- and satellite-based precipitation observations to the extent possible.

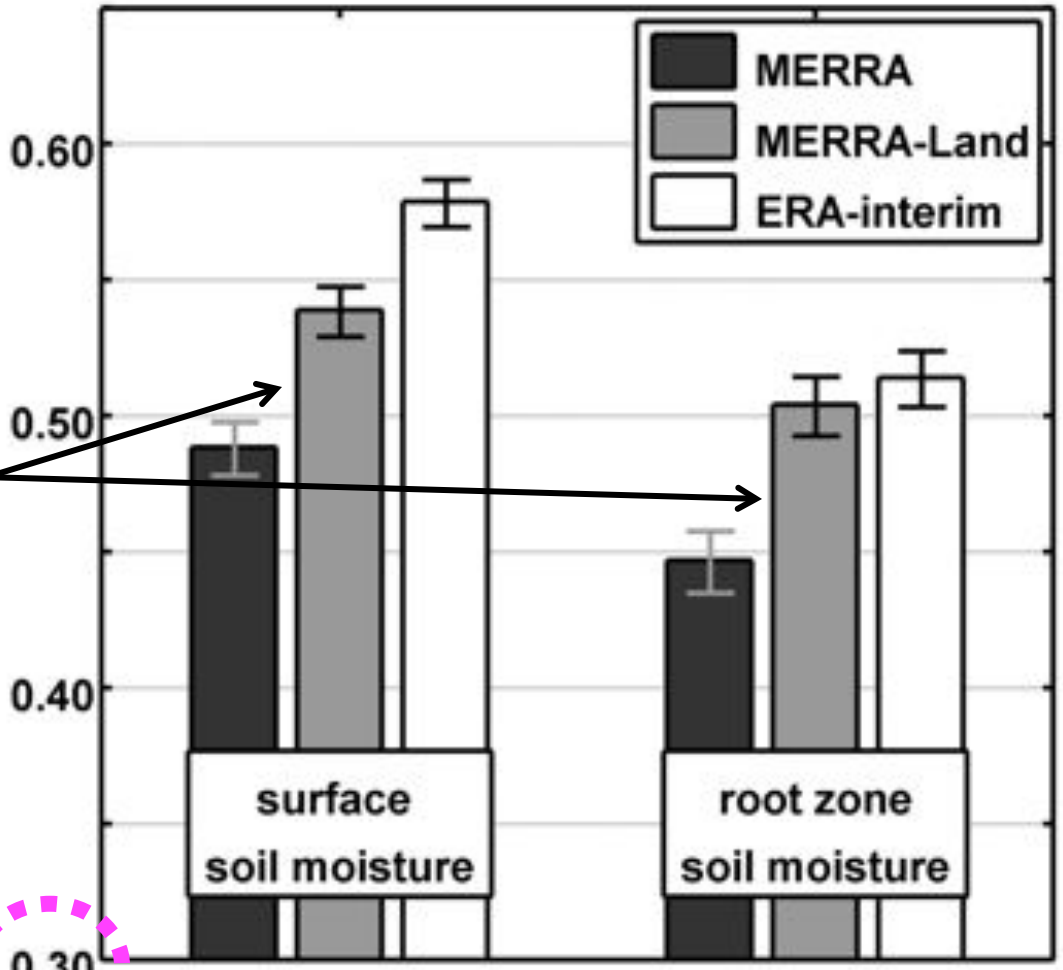
Reichle et al. J Clim (2011) submitted

Precipitation corrections



Soil moisture validation (2002-2009)

Pentad anomaly R
v. SCAN in situ observations

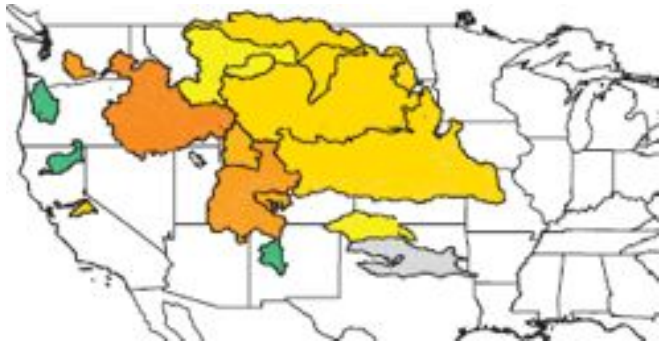


Better soil moisture anomalies (attributed to GPCP corrections).

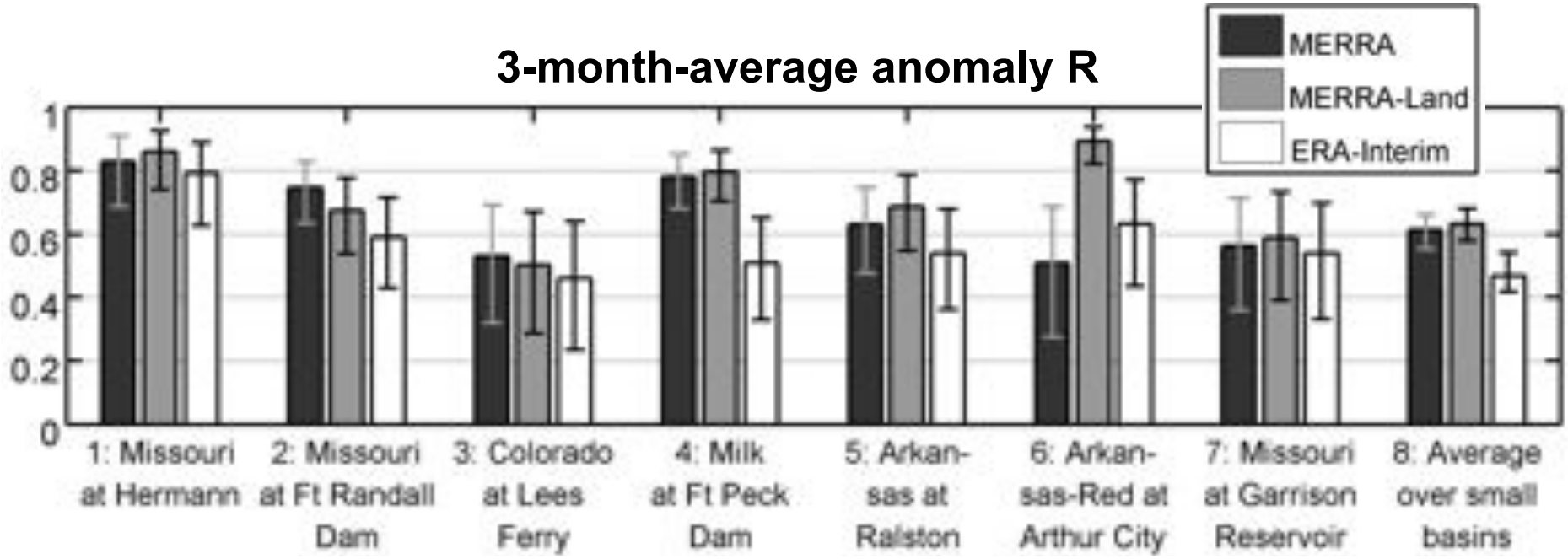
Additional analysis (not shown):

- MERRA skill comparable to ERA-Interim (if accounting for layer depth).
- Use of 5 cm surface layer depth in Catchment model is better (currently: 2 cm).

Runoff



Validation against naturalized streamflow observations from 7 “large” and 8 “small” basins (~1989-2009).



GPCP corrections yield significantly better runoff for Arkansas-Red.

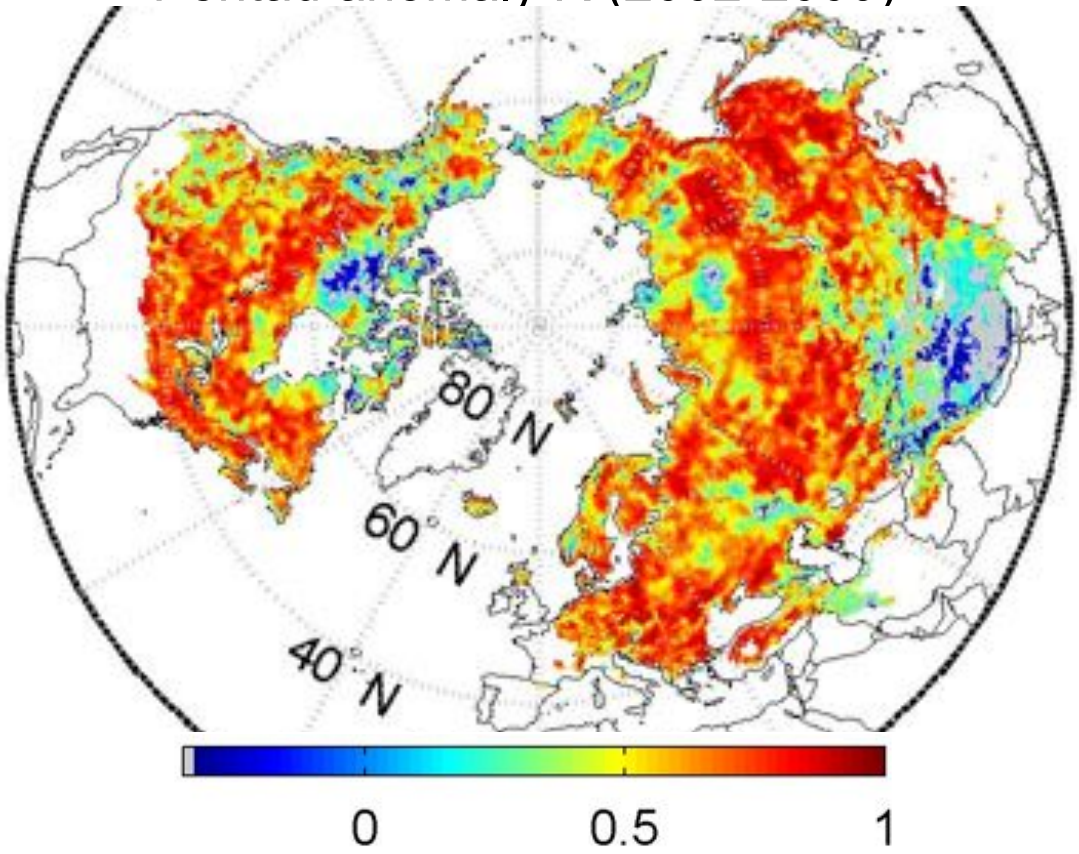
MERRA and MERRA-Land (0.5 deg) better than ERA-Interim (1.5 deg).

Not shown: In all cases the revised interception parameters yield improved runoff anomalies (albeit not significant).

Snow water depth

MERRA-Land v. CMC snow analysis

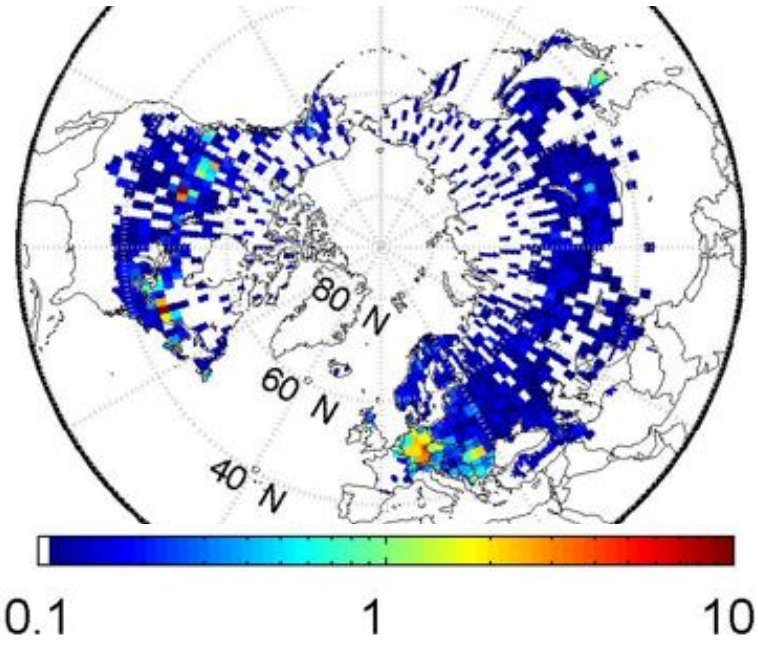
Pentad anomaly R (2002-2009)



Note: No snow analysis in MERRA or MERRA-Land.

CMC snow analysis

Density [stations/10,000 km^2]



MERRA and MERRA-Land have similar skill.

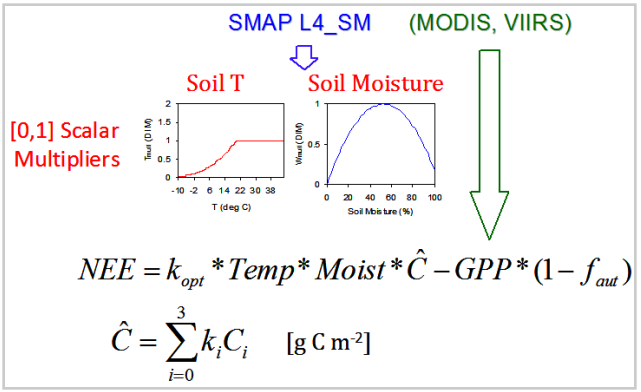
Low R values in areas without in situ observations.

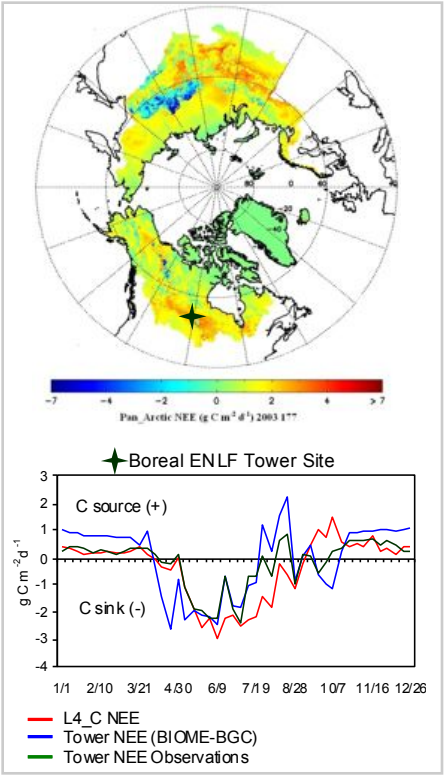
Not shown: Similar result for comparison against in situ data (583 stations) and for snow water equivalent (SWE).

L4_C baseline algorithm

Product: Net Ecosystem CO_2 exchange (NEE = GPP – R_{eco})

- **Motivation/Objectives**: Quantify net C flux in boreal landscapes; reduce uncertainty regarding missing C sink on land (NRC Decadal Survey);
- **Approach**: Apply a soil decomposition model driven by SMAP L4_SM & ancillary (LC, GPP) inputs to compute NEE;
- **Inputs**: Daily surface (<10cm) SM & T (L4_SM), LC & GPP (MODIS, VIIRS);
- **Outputs**: NEE (primary/validated); R_{eco} & SOC (research);
- **Domain**: Vegetated areas encompassing boreal/arctic latitudes (≥45 N);
- **Resolution**: 9x9 km;
- **Temporal fidelity**: Daily (g C m^{-2} d^{-1});
- **Latency**: 14-day;
- **Accuracy**: Commensurate with tower based CO_2 Obs. (RMSE ≤ 30 g C m^{-2} yr^{-1} and 1.6 g C m^{-2} d^{-1}).

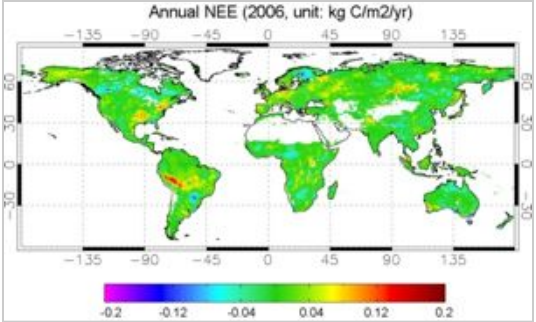




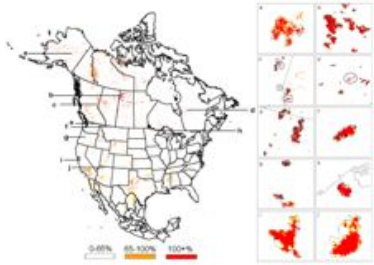
L4_C algorithm options

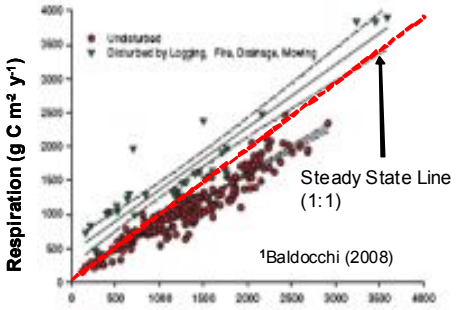
Several L4_C options are being evaluated based on recommendations from an earlier ATBD peer-review; options designed to enhance product accuracy & utility include:

- Global domain encompassing all vegetated land areas;
- Internal GPP calculations using SMAP L4_SM, L3_FT & ancillary land cover (LC) & VI (e.g. NDVI from MODIS, VIIRS) inputs;
- Represent finer scale (<9km) spatial heterogeneity consistent with available LC inputs;
- Explicit representation of LC disturbance (fire) and recovery impacts;
- Algorithm calibration using available observation data (FLUXNET, soil inventories).



Satellite driven [2]Disturbance Index (DI)



[2]Mildrexler *et al.* (2009)

[1]Succession/Disturbance Effects on Tower CO_2 Fluxes